CHAPTER 6
OPERATOR INTERFACES

6-1. General interfaces

Operator interfaces, or human machine interface (HMI) for SCADA systems provide the functions of status indication, alarm reporting, operator intervention in control action, and data storage and programming. Several levels or layers of operator interfaces are required to provide a reliable and maintainable system: equipment level, controller level, and supervisory level. At the controller and supervisory level, HMI may also provide capability to modify the controller program.

6-2. Equipment level

Equipment level HMI should consist at minimum of the control switches and indicators necessary to permit an operator to manually control the equipment in the absence of communications from the controller or for maintenance purposes. Examples of this level of control are hand-auto-off switches and indicator lights at motor starters; local-remote switches, potentiometers and meters at variable frequency drives; and circuit breaker control switches, meters and indicator lights at switchgear. Table 6-1 lists minimum manual control capabilities to be provided for mechanical and electrical system components:

Table 6-1. Minimum manual control capability

Function Identification	Function Description
	Standby Generation
G-1	Generator Set Start/Stop
G-2	Speed/Frequency Adjust
G-3	Synchronizing to Bus
G-4	Emergency Stop
G-5	Fuel Oil Pumps Start/Stop
G-6	Alarm Acknowledge/Reset
	Switchgear
S-1	Circuit Breaker Close (W/Sync-Check)
S-2	Circuit Breaker Trip
S-3	Lockout Relay Reset
S-4	Alarm Acknowledge/Reset
	Cooling Systems
C-1	Chiller Start/Stop
C-2	Pump Start/Stop
C-3	Fan Start/Stop
C-4	Setpoint Adjust
C-5	Valve Open/Close
C-6	Alarm Acknowledge/Reset
	Auxiliary Systems
A-1	Air Compressor Start/Stop
A-2	Sump Pump Start/Stop
A-3	Alarm Acknowledge/Reset

a. Manual control substitutes the facility operator for the automatic control system in the feedback loop, and leads to the risk of system or equipment mis-operation due to human error. Safety interlocks, such as motor overload, high-high pressure switches, fire detection, etc. should therefore be hard-wired into the control circuit such that they are active in both manual and automatic control modes. Switchgear protective relaying required for fault protection should always be hard-wired in the circuit breaker trip circuit and not dependent upon the controller.

b. In some cases, hard-wired manual controls for entire facilities have been centrally located in a control panel or benchboard at the control room. Although this simplifies operator intervention upon complete failure of the automatic control system, it is not recommended as the lack of physical segregation compromises reliability. A catastrophic structural or environmental failure at the control room would disable both automatic and manual control capability.

6-3. Controller level HMI

At the controller level, the primary HMI device should be a graphical display/keypad combination providing access to input and output data, timer and register settings, and alarm and status screens. These devices are commonly panel-mounted in the door of the PLC cabinet, and are available in enclosures suitable for hostile environments. With password-protected access control the controller level HMI may also provide a means of accessing and modifying the controller program logic. Table 6-2 lists the minimum recommended functionality of controller level HMI.

Table 6-2. Required controller level HMI functionality

Access Level[(1)]	Function Description
1	Alarm and Status Displays
1	Alarm Acknowledge
1	Initiate Pre-Programmed Control Sequence
2	Adjust Control Setpoints
2	Individual Device Start/Stop, Open/Close
2	Setup Data Trending/Reporting
3	Adjust Alarm Setpoints
3	Adjust Control Setpoint Ranges
3	Modify Controller Parameters
3	Modify Control Logic

[(1)] Increasing numbers indicate more restricted levels of operator access. Access levels are typically password-protected. Each access level includes the functionality of those below it.

6-4. Supervisory level HMI

Supervisory level HMI devices are typically personal computer workstations located in the central control room and/or management and engineering offices. The quantity and function of these workstations depends on the size and complexity of the facility. Simple facilities may be provided with a single workstation, which may be located in the main electrical or mechanical space in the absence of a central control room. Large or complex facilities should be provided with a minimum of two workstations in the

control room to permit operators to back one another up, plus the additional workstations required for engineering use, management overview, or data storage and reporting, as determined by the facility manager. Multiple-building campuses should be provided with workstations in the mechanical/electrical space of each major building to permit operations staff to obtain status and alarm information for the entire facility from any building.

a. Supervisory level HMI uses graphical screens displayed on the computer monitor to communicate system status and alarm conditions. Screens should be configured for facility overview, system overview, subsystem, and equipment screens for all major components of the facility. Remote manual control and supervisory control is typically performed at the supervisory level HMI under security access control. (See 7-3.)

b. Trending and data storage capability should be included in all SCADA systems to provide a permanent log of facility performance. All critical system parameters, such as temperature, humidity, voltage, current, should be stored every 15 minutes (or other specified preset time interval). The system should have the capability to record critical signal values more frequently at an operator-selected rate when prompted from the HMI or by a signal from operating equipment. The system should automatically return to its primary trending when system operation returns to normal. Data storage should utilize a separate server or drive from that used for the primary system control software and should be periodically backed up. Records should be maintained on-site for a minimum of 5 years.

6-5. Human factors

Design of HMI for SCADA systems must include consideration of Human Factors Engineering (HFE). It is estimated that 50 percent or more of all loss of load events in mission-critical facilities involve human action. A commonly reported scenario begins with a single component failure and correct response by the automatic control system to isolate the failure and maintain service to the load, however resulting in an off-normal system condition. Incorrect human intervention in attempting to restore the system to normal conditions then results in loss of service to the load. Consideration of HFE in the layout of operator controls can help prevent these occurrences.

a. Labeling: All control devices must be clearly labeled with letters that are large enough and provide high contrast with the background to be clearly legible in a hurry at a full arms length. The primary designation should be the functional description of the device, ex: “Generator No. 1 Speed Control”. The label should also carry the tag number of the device, ex: “43GS-1” that corresponds to the system documentation, but this information is secondary in emphasis and size to the primary designation.

b. Layout: Controls should be arranged and grouped in an intuitive and logical manner. Some of the many techniques that may be used to design intuitive layouts include:

(1) Grouping controls associated with individual pieces of equipment such as a chiller or a generator with substantial separation between groups.

(2) Placing control switches left-to-right, or top-to-bottom in the sequential order in which they are operated during a normal startup or shutdown.

(3) Spacing devices far enough apart so that labels are clearly associated with their device and an operator’s hand does not obscure the labels on adjacent devices.

(4) Arranging controls in the physical or electrical order of the process, using a mimic diagram or mimic bus.

(5) Color-coding control devices by function; ex: green start buttons, red stop buttons, yellow lamp test buttons, etc.

(6) Colored backgrounds or borders to emphasize grouping of controls on large control panels.

c. Color schemes: Color schemes used for controls and for graphic screens may duplicate color coding used within the process, such as piping color codes or system color codes, or may be developed strictly for the HMI. In all cases, colors should be selected to provide high levels of contrast without eye fatigue. Some rules for use of color in HMI displays are given in table 6-3.

Table 6-3. Rules for HMI colors schemes

Use colors with gray scale contrast ratios of approximately 3:7.
Use neutral background colors, such as light gray.
Limit the number of colors to seven, unless more are required, as for trend graphs.
Sixteen colors are sufficient for 95 percent of all applications.
Use the standard Windows® interface colors listed in table 6-4.
Observe industry standard color conventions; red for breaker closed, green for breaker open, etc.
Use color consistently between screens.

d. Select-before-operate: HMI software should be programmed such that an operator must select the device to be controlled by point-and-click or other means and then select the operation to be performed. This two-step requirement for manual control can reduce errors resulting from selection of the incorrect device. Selection of a device to be controlled should result in highlighting that device on the screen, providing the operator a visual verification of correct selection.

Table 6-4. RGB values for standard colors

Color	Red Tint	Green Tint	Blue Tint
Black	0	0	0
White	255	255	255
Dark Grey	128	128	128
Light Grey	192	192	192
Dark Red	128	0	0
Bright Red	255	0	0
Amber	255	202	0
Bright Yellow	255	255	0
Dark Green	0	128	64
Bright Green	0	255	0
Dark Cyan	0	128	128
Cyan	0	255	255
Dark Blue	0	0	125
Bright Blue	0	0	255
Purple	128	0	128
Magenta	255	0	255